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MASTER OF MILITARY STUDIES

THE CH-53K: ARE WE PURCHASING THE RIGHT AMOUNT?

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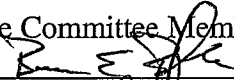
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Executive Summary

Title: The CH-53K: are we purchasing the right amount?

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Thesis: If the Marine Corps continues to move forward with the purchase of heavier equipment, they must increase the number of CH-53K's purchased in order to allow the MV-22B's and CH-53K's to efficiently conduct Ship to Objective Maneuver (STOM) forcible entry (FE) mission criteria to a distance of 110 nautical miles.

Discussion: The U.S. Marine Corps is in the process of modernizing the aircraft in its inventory with next generation capabilities. These upgrades combined with today's changes in Marine Corps combined arms doctrine makes it necessary to look at the acquisition process to ensure that the Marine Corps address how either modified or new equipment will operate under this new environment. The current design of the MV-22 should allow it to carry a 10,000-pound vehicle out to 115 nautical miles, although some reports suggest that it will only be able to carry the weight out to 40 nautical miles. These are obvious concerns considering the MV-22 is to be the backbone of the future STOM mission and the limited amount of CH-53Ks will not be able to make up the shortfall. The CH-53K, however, will successfully meet all future Marine requirements, with a built-in margin. The planned metric of 110 nm radius and a payload of approximately 15 tons will successfully meet the STOM requirement of lifting a light armored vehicle or equivalent into combat. Not only will the CH-53K double the lift capability of the aging CH-53E, it will also have significant cost benefit. One major concern with both the MV-22 and the CH-53K is that future Marine Corps gear is continually becoming heavier. This is due to the necessary increase in protection that is required out of the new equipment. Due to this weight increase, the CH-53K will quickly become the only viable heavy lift helicopter that can meet a 2015 to 2020 MEB operational requirement.

Conclusion: Over the years, the Marine Corps has become wedded to the MV-22 plan due to a number of internal factors. It becomes inherent that the Marine Corps conduct a detailed study of the future design capabilities of the CH-53K and the MV-22B to help determine the lift requirements for assault support aviation. The Marine Corps should also look at the CH-53K and MV-22 to determine the correct mix of aircraft that will successfully accomplish all future operations.

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Introduction

Currently, the U.S. Marine Corps is in the process of modernizing the aircraft in its inventory with next generation capabilities. These upgrades combined with today's changes in Marine Corps combined arms doctrine makes it necessary to look at the acquisition process to ensure that the Marine Corps address how either modified or new equipment will operate under this new environment. In January 2006, Colonel Paul Croisette of Program Manager, Air (PMA) 261 stated that,

since the first Gulf War, Marine Corps vertical heavy lift has been getting further and further away from the original requirement it was developed to meet, a behind the lines logistics support aircraft. From the Scott O'Grady rescue mission on June 2, 1995 in the Balkans, to delivering critically needed combat support in Afghanistan, Iraq, and the Horn of Africa, we're wearing out the aircraft because it has been in incredibly high demand since the mid '90s.¹

Due to these ongoing missions, the Marine Corps is now beginning to address obsolescence, maintainability and reliability within the heavy lift community. It is essential to assess the associated impact on amphibious lift and the logistics resupply of Marines before the acquisition of any modified or new equipment. It becomes inherent that the Marine Corps conduct a detailed study of the future design capabilities of the CH-53K and the MV-22B to help determine the lift requirements for assault support aviation in the future.

The CH-53K program was given the go ahead by the under secretary of defense for Acquisition, Technology and Logistics on 22 December 2005. The MV-22, on the other hand, is currently in full production and moving to its second year of deployments. Since both of these platforms are the future assault-support aircraft for the Marine Corps, it is important to conduct a thorough research on the CH-53K's and MV-22's capabilities so the Marine Corps can accurately define the future of the heavy and medium lift communities. Both the CH-53K and

the MV-22 can accomplish many of the assigned assault support missions, however, with Marine Corps gear getting heavier, the ability of the MV-22 to external gear over the horizon as originally planned may no longer be an option. The obvious advantage of the MV-22 is its ability to fly long distances at a greater speed. The CH-53K, utilizing its refueling probe, can accomplish the same task carrying three times the weight of the MV-22. Ultimately, the extra amount carried by the CH-53K will actually save time during a critical resupply mission.²

Using technology, the Marine Corps must update and simplify the current arsenal to allow the continued support the troops with most capable equipment, all while reducing the cost burden on the tax payer. Although technology cannot change the fundamental nature of war, what has become an important aspect of modern warfare is the focus and reliance of speed, stealth, precision and sustainability.³

This paper will examine whether a MEB or MEU can logistically sustain forces ashore utilizing assault support aircraft. As the Marine Corps continues to modernize their fleet of equipment, they must look at the critical issues that increasing the weight of ground tactical vehicles will cause to the aviation assault-support community. If the Marine Corps continues to move forward with the purchase of heavier equipment, they must increase the number of CH-53K's purchased in order to allow the MV-22B's and CH-53K's to efficiently conduct Ship to Objective Maneuver (STOM) forcible entry (FE) mission criteria to a distance of 110 nautical miles.

The CH-53

Before looking at the future assault-support requirements, it is necessary to look at the history of the CH-53 helicopter. In August 1962, the Marine Corps was in search for a new heavy lift helicopter and placed its initial order for the CH-53A Sea Stallion (Figure A). At that

time, the CH-53A was the largest helicopter design available to the U.S. Navy. The CH-53A's primary mission would be the movement of cargo and equipment. It would have a secondary task of transferring troops ashore in an amphibious assault. The CH-53A was successful, but the Marine Corps would soon look for a platform with greater lift capabilities. Sikorsky was quick to design the CH-53Ds (Figure 2), which housed new improved engines and would have increased power to recover downed aircraft, sweep mined areas and, if necessary, tow distressed ships. Vietnam's environment created power issues for the CH-53D, so again Sikorsky would begin to produce an aircraft with increased capabilities and they would call it the CH-53E (Figure 3). It is an obvious design derivative from its smaller CH-53 brethren. However, there were many major changes required in order to make CH-53E provide the largest lift capability in the free world. The Marine Corps at this time recognized the need for increased lift capability, but nowhere near what the Army would require in its HLH (heavy lift helicopter) program. The Marine Corps, Naval Air Systems Command and Sikorsky combined their forces to develop the CH-53 from a 10-ton to a 16-plus-ton lifter. In December 1980, the first production aircraft flew and given to HMH-464 in mid-1981. On 23 November 2003, the last Super Stallion helicopter arrived at HMH-461, nearly 23 years after the first CH-53E made it to the fleet.⁴ The aging fleet of CH-53E's has been successfully supporting Marines on the ground for nearly 30 years.

Future Heavy Lift Options

Shortly after the assembly line for the CH-53E closed in 1999, the Marine Corps began looking at two options for the future of heavy lift helicopters. The Army again brought up the option of a Joint Heavy Lift Helicopter (JHL) (Figure 4), while Sikorsky began using the existing CH-53E to develop a new, improved design, which they designated the CH-53X. The requirement that the Army put forth was a proposal to transport their Future Combat Systems

that far exceeded the Marine Corps requirement, suggesting that the airframe would be too large to operate from current and future naval shipping. Although Congress did retain the ability to force the JHL helicopter design, they ultimately approved the Sikorsky variant for the Marine Corps, allowing them to sign the contract for 156 CH-53K helicopters (Figure 5) in early 2006. As it currently stands, flight-testing will begin in 2011, with service introduction in 2015 and final deliveries in 2022.⁵

The CH-53K will have many improvements over that of the current CH-53E. Even with the many new technologies being considered for the CH-53K, the main improvements will include a joint interoperable glass cockpit, high-efficiency rotor blades, a low-maintenance elastomeric rotorhead, upgraded engines, external cargo improvements, survivability enhancements, and enhancements designed to extend service life. The combination of new technologies will allow the CH-53K to have a 10,000 hour design life, almost double the hours of the current CH-53E. In addition, by moving away from the fault based maintenance program to a conditional based maintenance program, the Marine Corps has set its goals on reducing the 44 maintenance man hours per flight hour inherent to the CH-53E by half. In 1999 dollars, the operational cost of the CH-53E was approximately 20,000 dollars per flight hour. The CH-53K program has set its sight on a more reasonable 10,000 dollars per flight hour.⁶

The CH-53E can carry 32,000 pounds of cargo externally at a cruise speed of 100 knots to a range of 50 nautical miles at sea level on a tropical day. The CH-53K is currently being designed to factor the effects of "high, hot and heavy" in order for it to carry 30,000 pounds of cargo at 100 knots at 3,000 feet to a range of 110 nautical miles. Utilizing these parameters, the Marine Corps can more accurately duplicate the environmental conditions in which the aircraft would be operating. By simulating the worse case scenario, they would not run into the

problems of the past where the designed in planning numbers were closer to the best-case scenario. The current design of the CH-53K will allow it to accomplish all future resupply missions since it will double the lift capacity and radius of the current CH-53E. The result will be a much more capable helicopter.⁷

Why not upgrade the CH-53E?

The deployed CH-53E helicopters in Iraq are flying approximately three times the planned utilization rate, moving the average airframe hours to roughly 5,000. The ongoing operational pace is resulting in higher airframe and component repair costs, ultimately increasing the amount of short-term fatigue repairs required to minimize future CH-53E inventory reductions. At the same time, the average age of the fleet of CH-53Es is over 15 years old. All these factors forced the Marines to look at a service life extension program (SLEP) in the late 1990's. During the early stages of SLEP, the Marine Corps would run into many issues regarding maintainability throughout its research. Due to the increase in maintenance man hours and cost per flight hour over the past years, the Marine Corps began to seriously look at a new airframe. Still the most notable cause for the shift is due to the attrition of the CH-53E in the last decade, resulting in the return of decommissioned CH-53E helicopters to operational status. Currently, there are no more CH-53E aircraft at the storage facility in Tuscan, Arizona and the Marine Corps is in the process of acquiring the outgoing MH-53E's, the Navy minesweeping helicopter, for conversion to the CH-53E variant. The conversion process will temporarily fill the gap, but there will still be a need for the CH-53K as a replacement. Even if the Marine Corps could maintain the requisite number of CH-53E aircraft to conduct the SLEP, there would still be a capability shortage when trying to execute future Marine heavy lift requirements.⁸

Since SLEP comes up often when military equipment begins to age, it is important to research what other previous programs may offer when trying to extend the life or use an existing platform to produce an improved aircraft for future requirements. One such case is the Air Force F-84F program from the late 1940's to early 1950's. Due to a change in requirements, the Air Force looked for an aircraft with increased performance and ordinance capability. Republic, builder of the F-84 series, offered a proposed low-cost aircraft that would be a mere modification of the existing F-84E. The redesigned swept wing variant was to utilize 55 percent of the F-84E tooling in the new production. Almost as soon as they began producing the F-84F, Republic and the Air Force realized there were deficiencies with the engines. Republic then began to redesign much of the fuselage to accommodate the required, more powerful engines. Since the F-84F encountered many design changes, the aircraft would only use approximately 15 percent of the existing F-84E tooling in the design. The decision to modify the existing airframe to accommodate a new requirement would ultimately cost the Air Force 3 times of the original planned target cost.⁹

Another recent program that has experienced its share of problems is the upgrade to the AH-1W Cobra and the UH-1N Huey. The original plan for the H-1 upgrade program was to remanufacture the current lot of AH-1Ws and UH-1Ns and at the same time utilize 84 percent commonality of parts to create the UH-1Y and AH-1Z aircraft. In April 2005, due to multiple problems with airframe conditions and downtime, the Marine Corps received approval for the new-build UH-1Ys after remanufacturing only a handful of old UH-1N helicopters. A few years later a decision came down to build the last 40 AH-1Zs as new aircraft since there was a concern that the AH-1W would be too old and worn-out to remanufacture cost-effectively due to their heavy use in Afghanistan and Iraq. Eventually, the high deployment and utilization rate of the

AH-1 caused the Marine Corps to move the build of the brand new AH-1Z's to the front to keep from having an aircraft shortage during the ongoing wars. All of the changes internal to the UH-1Y and AH-1Z program created significant delays and cost growth in the manufacturing of initial production aircraft, leading to 140 percent cost growth and 36 percent schedule growth.¹⁰

Realizing that the days of storming the beach by traditional means and tactics would be limited in the future, the Marine Corps envisioned the transportation of Marines and equipment by future aircraft from the ship to a secured inland landing site up to 110 nautical miles away. Studies and history has proven that a remanufactured CH-53E may be able to accomplish this mission, but in the end, it would cost more money and ultimately lie on the backs of the Marines. Now that OMFTS, STOM, and FE are the concepts of the future, the Marine Corps will have to make sure that they continuously study and refine their future equipment in order to retain their relevance far into the future.¹¹

The CH-53K, however, will successfully meet all future Marine requirements, with a built-in margin. The planned metric of 110 nm radius and a payload of approximately 15 tons will successfully meet the STOM requirement of lifting a light armored vehicle or equivalent into combat. Not only will the CH-53K double the lift capability of the aging CH-53E, it will also have significant cost benefit. The CH-53K program is the only viable heavy lift helicopter that can meet a 2015 to 2020 MEB operational requirement.¹²

The V-22

Since Marines deploy aboard amphibious shipping, the service chiefs have always hungered for the capability of an aircraft that could take off from ships and drop their combat-ready troops over the horizon. As the Marines' Vietnam-era CH-46s began to age, the Marines

started to consider an aircraft that would allow more options when conducting amphibious assaults. In April 1980, the failed Desert One mission to rescue the sixty-six American hostages in Iran deepened the needs of the services. At that time, no military service had the capability to deploy a helicopter package unrefueled to an unimproved landing zone over the horizon. The requirements shortfall pushed the services to pool their resources together to prepare for Operation Eagle Claw. The operation proved to be disastrous due to the lack of training and the failure of the various services to work together as a cohesive force. During the unsuccessful operation, the services lost eight helicopters, one colliding with a C-130 aircraft after a refueling evolution, killing eight U.S. service members. A result of the negative publicity pushed Pentagon officials to look for a transport that all four services could use to guarantee there would never be another Desert One incident. Considering the failure, the Special Operations Forces (SOF) requirement came together for what was to become the CV-22. Once President Reagan entered office, he immediately increased the budget to the Department of Defense, which allowed an increase in funding for research and design of new weapons and combat systems. Out of these budget increases, the V-22 Tilt rotor Figure 6) was born.¹³

The Marine Corps will generally boast that it only spends roughly one nickel out of every Department of Defense dollar. For that reason, they have successfully operated with limited funds by adopting the philosophy of "we do more with less" and by acquiring cheaper weapons than the other services. The story of the V-22 contradicts this belief by becoming a program that has spent billions prior to the first aircraft hitting the fleet. With more than twenty-five years in development, the V-22 program proves the inherent shortfalls of a military service with little oversight experience. The Marine Corps performance with this program has resulted in a

radically designed aircraft that is as notable for its shortcomings as well as its technological advances.¹⁴

The Pentagon has currently invested more than 27 billion dollars in the V-22 program and is on track to spend 35 billion more before the program is complete. The continuing investment will give the Marines, Navy and Air Force 458 aircraft at an average of 118.4 million dollars per copy.¹⁵ This is much greater than when the program was originally proposed, since it was to churn out roughly 1,000 V-22s in less than 10 years to all the services at a per copy price of 40 million dollars. Given the V-22 cruises similar to an airplane and takes off and lands like a helicopter (Figure 7), its progress has gone through a number of technical challenges and price increases throughout its lifecycle. As time passed and the expenses rose, the Army began putting more focus on their helicopter programs and subsequently dropped out of the V-22 program. Due to the Army falling out of the program, the overall unit price increased dramatically.¹⁶

It is now time to look at the pros and cons of the V-22 aircraft. An important facet of the V-22 is that it can fly into harm's way at more than 200 miles per hour, convert to helicopter mode and then land within seconds. It will then quickly pause on the ground to deliver or pick up Marines and then push from the landing zone and return to base. The V-22 flies at twice the speed of any helicopter, giving the Marines much greater range than previously possible. Furthermore, the aircraft bridges the gap between the helicopter and a C-130 concerning the transporting of personnel or gear. The extended design phase of the V-22 allowed them to incorporate various missile-warning systems and fire-extinguishing equipment to strengthen its survivability. If the hit by surface fire, the V-22s redundant hydraulic and flight-control systems may allow it to fly from the danger area.¹⁷

Since the MV-22 should have already replaced the venerable CH-46 helicopter years ago, it has become the Marines top aviation priority. It is critical that Marine Corps focus on the shortfalls of the MV-22 and attempt to get solutions as we continue to implement them into the fleet. An issue of concern with the MV-22 is the Marine Corps are using the planning factor of carrying 24 combat loaded troops. When the Marine Corps conducted testing, they used a ballast weight of 4,760 pounds in lieu of the actual twenty-four combat equipped Marines, which translates to a highly unlikely estimate of 198 pounds per body. The average Marine carrying rifle, ammo, and full combat pack are roughly 250 pounds. Using the test figures and allowing for a modest sixty pounds of gear put each Marine body weight at roughly 138 pounds. Operations in Iraq and Afghanistan have proved this shortfall in testing with the V-22 only being able to carry ten to twelve combat loaded troops. The reduction in carrying capacity is not as much a weight issue, but mostly due to the small cabin size. This factor can create a shortfall that will expand the amount of time required to get the requisite forces ashore by almost fifty percent.¹⁸

Another critical issue plaguing the MV-22 is that it has no capability to employ door gunners because the wing and engine block their field of view. Also due to the speed of the aircraft, there is a reduction to the gunner's accuracy due to the gun being in the wind stream. Currently, the only weapon on the MV-22 is a M240, 7.62 caliber machine gun mounted on the tail. The V-22 program has attempted numerous times to acquire a turret style, chin mounted, .50 caliber machine gun giving the aircraft a suppressive fires capability (Figure 8). The issue with this system was that the Marines became concerned about the inherent loss of performance and speed the system would cause to the V-22. The Air Force Special Operations Command is on track to install the BAE all-quadrant, 7.62mm Gatling gun in the hellhole space located on the

belly of seven CV-22 Ospreys in 2009. Once the gun is qualified, the Marine Corps will determine how to best deploy the gun on the MV-22. The acquisition of this gun will have shortfalls for the Marine Corps, since they require the use of the hellhole when conducting external operations.¹⁹

Until the acquisition and installation of an offensive weapon, the V-22s will be highly dependent on Cobra escorts, possibly causing them to fly as slow as helicopters and negate their only advantage. Due to the V-22's speed and range, there is no current or future escort helicopter capable of escorting it over the horizon into enemy territory. The Marine Corps has considered many options, from the use of fixed wing aircraft, building a V-22 gunship, unmanned attack vehicles or having the AH-1 Cobra gunships launch early by utilizing a refueling platform to extend their range. As it stands, the near term solution will be the utilization of the Cobra gunships using a CH-53 to extend the range through Tactical Bulk Fuel Delivery System (TBFDS). With the lack of threat to enemy air, using the AH-1 and CH-53 creates a viable solution to the current problem. As soon as an air threat returns, the Marine Corps will be required to implement the use of fixed wing or unmanned aerial escort.

Due to the aforementioned issues, having other Marine Corps MEB or MEU aircraft supporting the V-22 will likely take away from the primary resupply missions. The required support will hinder the CH-53's mission of resupplying forces, if they are conducting TBFDS for the AH-1. Currently, the AV-8B Harrier is the only capable MEB or MEU aircraft that can fly over horizon and escort the MV-22. The problem with the AV-8 is that it does not have the capability to hold at an altitude appropriate to give the MV-22 continuous eyes on the objective, as does an attack helicopter. When looking at what will be required during future MEB and

MEU operations, the utilization of the MV-22 will cause a self-induced sortie reduction and greatly reducing the logistics capability.

Future Ground Equipment

Similar to Marine aviation, the ground combat elements' (GCE) equipment is also in the process of major modernization. The ongoing operations around the world have increased the wear and tear, not only to Marine aviation, but also to the GCEs' equipment. For this reason, the Marine Corps has begun to enhance their focus on the management of their current arsenal and at the same time pursue a number of new ground capabilities. To accomplish these goals, the Marine Corps is currently investing a great deal of funds in the modernization of most equipment, vice simply upgrading the old equipment.²⁰

It is obvious to see that the future Marine Corps gear is only going to become heavier. This is due to the necessary increase in protection that is required out of the new equipment. Previously, the Marine Corps would look to acquire equipment that would fit on amphibious shipping, with weight being one of the big considerations. Although the mindset of the Marine Corps has not changed, the war in Iraq would put them in a precarious position with the acquisition of equipment such as the Mine Resistant Ambush Protected (MRAP). The fifteen to thirty ton MRAP does enable greater protections to our troops against improvised explosive devices, but the rapid introduction did not allow a complete evaluation period to determine if they would be shipboard or airborne compatible. For the Marine Corps, this tends to create a problem since they are amphibious by nature and move around on ships. Not only is the MRAP, in all variants, too heavy for amphibious or airborne operations, their extreme weight and high center of gravity make them nearly impossible to use in places like Afghanistan, due to its

austere environment. The Commandant of the Marine Corps, General James Conway said, "He did not know what the Marines would do with the vehicles once the roadside bomb threat subsided. The Marine Corps is a light, rapid-reaction force and would be bogged down by the massive MRAPs."²¹

The Marines are also pursuing a number of new ground capabilities, which will include a new Expeditionary Fighting Vehicle, a new armored Marine Personnel Carrier, and a new Joint Light Tactical Vehicle (JLTV). All these vehicles will be much heavier than their respective replacement. The JLTV is currently a multi service program that will eventually be the replacement to the High Mobility Multipurpose Wheeled Vehicle (HMMWV). Since the JLTV will be significantly larger and double the weight of the current HMMWV, thorough research on how this new vehicle will fit into the Marine Corps' future concepts needs to be completed. Lacking the appropriate attention to this issue may not only present a problem to shipboard operations but also to the accomplishment of STOM using assault support aircraft. When STOM was designed, the plan was for the V-22 to be able to pick up one HMMWV externally while the CH-53K would either carry one internal and one external or two external. The development of the JLTV in all future configurations will be too heavy for the V-22 to external. At the same time, the CH-53K may not be able to carry two JLTVs, depending on the configuration.²²

Operational Maneuver from the Sea

In the 1930's, the Chief of Naval Operations and Commandant of the Marine Corps had a vision of what the Naval forces should be able to accomplish. This would cause them to develop the White Papers, "... From the Sea" and "Forward ... From the Sea," in order to place

unprecedented emphasis on the littoral areas. These papers would become the basis for the concept of the naval expeditionary force.²³

Operational Maneuver from the Sea (OMFTS) builds on the foundation laid out in ". . . From the Sea" and "Forward . . . From the Sea." The definition of OMFTS is the rapid maneuver and employment of landing forces from amphibious shipping to objectives ashore. OMFTS focuses on an operational objective, uses the sea as maneuver space, generates overwhelming tempo and momentum, pits strength against weakness, emphasizes intelligence, deceptions, and flexibility, and integrates all organic, joint, and combined assets.²⁴

OMFTS enables the Navy and Marine Corps to control the littoral regions even though they are a relatively small portion of the world's surface. This is vital since the littorals are home to over three quarter of the world's population, the location of over 80 percent of the world's capital cities, and encompass nearly all the major places of international trade. Due to these facts, the littorals are where most of the world's major conflicts will likely occur in the future.²⁵

The current arsenal of aviation and ground equipment utilized by the Marine Corps can accomplish the original concept of OMFTS. When the Marine Corps designed the CH-53E and the CH-46E, they focused on carrying cargo and personnel to a range of 50 nautical miles. In the 1970's and 1980's, the Marine mission was to storm a beachhead in order to gain access ashore. Over time, the Marine Corps would find inefficiencies due to the rudimentary technology utilized during amphibious assaults. There were many undue delays by both Marine aviation and the GCE, because of the mandatory uses of operational phases, pauses and reorganization in ship to shore operations. The result was a time-consuming buildup ashore as the watercraft executed an intricate plan of shuttling personnel and equipment to the beach. After getting ashore, the landing force had to secure a lodgment until they could build up sufficient combat power. Soon

after, the landing force was to maneuver from the shore to the actual objective, which added more time to the equation. The critical reason for establishing such a beachhead was to build up in the littoral area that was vulnerable to attack.²⁶ At this time, the CH-53E, MV-22 and the CH-46E have the capability to conduct OMFTS to a limited distance. If there is a requirement to move further inland and establish a lodgment, further research must be conducted in order for the successful accomplishment of the mission.

Seabasing

Seabasing is the rapid deployment, assembly, command, projection, reconstitution, and re-employment of combat power from the sea. Seabasing will provide continuous support, sustainment, and force protection to expeditionary forces without reliance on land bases. Seabasing will expand operational maneuver options and allow access and entry from the sea.²⁷ It will also enable the accelerated deployment and employment of naval power-projection capabilities and enhance seaborne positioning of joint assets. The greatest benefit will include the reduced requirement to build up a large logistics base ashore and reduced demand on strategic airlift assets.²⁸ On the other hand, the reduced demand on strategic airlift assets will have an inverse reaction for MEB or MEU aircraft, ultimately causing a greater demand for the CH-53 and MV-22.

The focus of seabasing is to enable the early arrival and synchronization of joint force capabilities into theater to provide strategic speed, access, and persistence for military operations. The main objective of seabasing is to take advantage of the capabilities of forward deployed and pre-positioned forces. Seabasing achieves forward presence capability to both the conventional and unconventional threats. It will improve operational tempo while seizing the

initiative without operational phases, pauses and reorganization that normally is associated with amphibious assaults to a beachhead. Due to the reduction of personnel and a large logistics hub ashore, it will decrease the force protection challenges we currently face today. Lastly, seabasing allows the Joint Force Commander the ability to exploit the maneuver space inherent to the sea in order to gain capabilities and advantages over the enemy.²⁹

As the Navy and Marine Corps get closer to adopting the seabasing concept, the Chief of Naval Operations (CNO) requested the Center for Naval Analysis (CNA) staff to examine whether or not the future vertical lift provided by the CH-53Ks and MV-22s of a MEB could accomplish sustained seabase-to-shore operations. The CNA would focus on whether this would be feasible by air in a ten-hour period and operating from LHA/Ds. The study would utilize the future MEB allotment of 48 MV-22s and 20 CH-53Ks to come up with there best case results.³⁰

In the study, CNA acquired inputs from N42s Sea Basing Logistics Enabling Concepts and briefings from Marine Corps Combat Development Command to get their assumptions for re-supplying forces ashore. CNA not only looked at whether the helicopters could maintain the operation tempo, but if the ships would be able to sustain the re-supply. When CNA studied the two aircraft, they had to make a number of assumptions based on aircraft availability, ship capability, fuel requirements, and lift capability.

CNA ran models of three different allocations of aircraft on MEB shipping. The results of the study showed that spreading the CH-53Ks evenly over the three ships extended the resupply time by a considerable amount. By having the preponderance of the CH-53Ks on one LHD, it minimized the resupply time, which allowed completion within ten hours. The downfall of putting all the CH-53Ks on one LHD is the reduced availability outside the initial ten-hour window. Since the CH-53K can carry three times the weight of the MV-22, the model results

would emphasize the importance of the CH-53K when supplying forces ashore. On the other hand, since the MV-22 can only carry one-third the weight of the CH-53K, it makes them less crucial when aircraft availability issues arise.

Currently, the MEB air combat element will consist of forty-eight MV-22s. Recently the Marine Corps has discussed reducing the number to forty MV-22s. This of course would adversely affect the time required to deliver supplies ashore. If there were a reduction of eight MV-22 on the amphibious shipping, it would free up six additional spots, which the CH-53K can occupy. The extra CH-53Ks would offset most, if not all, of the lost lift due to the reduction of MV-22s.

In the end, the results that CNA achieved are that the logistics support to multiple brigades is attainable in a 10-hour period by the MEBs aircraft. The critical concerns relate to the time it takes to build and position the sheer number of external loads on flight deck. In addition, it is difficult to consider the weight and aerodynamic impact the loads will have on the MV-22. These concerns are critical to an aircraft such as the MV-22, since it is far less efficient when flying in transition mode. The study determined that the CH-53K was critical to any resupply mission due to the amount of weight they can carry. When the distance is increased the CH-53K lift capability will become more critical to the resupply effort. In addition, CNA concluded that the increased number of CH-53Ks could alleviate the logistics strain when time becomes a factor.³¹

Forcible Entry

As the Marine Corps continues to study future amphibious concepts, it is inherent that they also continue to refine and enhance our capabilities for forcible entry (FE) from the sea. FE is

“A joint military operation, conducted with the expectation of armed opposition, which gains entry into the territory of an adversary in order to achieve a coup de main or enable the conduct of follow-on operations.”³² As the population of the world grows, we will more frequently find ourselves fighting within one hundred miles of the littoral regions. Since this will be the case, we will need to continue to utilize our technology to expedite deployment capabilities all while reducing our footprint ashore.³³

As stated in previous National Defense Strategy documents, the Marine Corps must be prepared to conduct FE in any clime or place. The documents assert that FE be initiated on a compressed timeline, by dispersed forces in multiple locations across significant distances all having varying degrees of access. Previously, the Marine Corps had the luxury of setting up for entry, position resources, establish forward operating bases and build up force levels. In the future, this will not be the case, since it has become much more difficult to attain permission to stage large ground forces.³⁴

Since it is unlikely that a helicopter gunship will escort the MV-22, the Marine Corps must find an alternate way to conduct the FE mission safely when utilizing the MV-22 aircraft. In addition, because the MV-22 lacks an offensive weapon, it does not have the capability to operate independently over the horizon. Until there is a viable escort platform for the MV-22, the Marine Corps will have to rely on both fixed wing and other assault support assets to provide the protection required to conduct the FE mission.

Ship to Objective Maneuvering (STOM)

OMFTS is the foundation for what the Marine Corps is ultimately trying to achieve in its amphibious doctrine. Seabasing follows suit by setting the stage for the Marine Corps to conduct

amphibious FE with the use of STOM. STOM is a relatively new tactical concept for amphibious operations that will exploit advanced technologies and permit combined arms maneuver from an over the horizon seabased position. The concept requires the use of the emerging technology included in the Advanced Amphibious Assault Vehicle (AAAV), CH-53K, and MV-22. Exploiting their over the horizon capability via the land and sea, directly to inland objectives, the Marine Corps will be able to accomplish distant mission that were previously considered to difficult and dangerous with the current arsenal. Utilizing the MV-22 and CH-53Ks ability to aerial refuel and the speed of the AAAV, the Marine Corps can expedite the movement of forces ashore over a greater distance.

The MV-22 and CH-53K offer the required mobility to enable the vertical assault force to attack and strike from over the horizon at deep objectives, reembark, and strike other objectives before the enemy has time to react. STOM will free commanders from the constraint of securing beachheads and allow them to begin focusing on the enemy earlier than in the past when commanders had to consider the intricacies of building up forces ashore. In addition, STOM will allow commanders to operate from the ship and exploit enemy weaknesses while maintaining the momentum during the attack. Utilizing the aforementioned equipment and warfare philosophy, the STOM concept will allow the Marine Corps to become a more effective combat force for the future.³⁵

A current issue related to STOM is the MV-22s inability to carry an up armored HMMWV on its single cargo hook. When the Marine Corps conducted the original operational tests, they used a 7,200-pound unarmored HMMWV. Today, because of the IED threat, there very few unarmored HMMWVs left in the inventory. The up armor kit adds roughly 2000 pounds to the base weight of the vehicle. The Marine Corps has yet to certify the MV-22 to carry the up

armored HMMWVs due to the weight of the vehicle approaching the max weight in which the MV-22 can carry. Ultimately, the MV-22 should be able to carry a 10,000-pound vehicle out to 115 nautical miles, although some reports suggest that they will only be able to carry the weight out to 40 nautical miles. These are obvious concerns considering the MV-22 is the backbone of the future STOM mission and the limited amount of CH-53Ks will not be able to make up the shortfall.³⁶

Conclusion

As the future Marine Corps equipment gets heavier, it requires a full study of the aviation and ground programs to make sure we can continue to operate efficiently in these difficult and changing times. If the Marine Corps continue on the same path that they have in the past and purchase equipment without fully studying, testing and understanding what the future requirements are, they will continue to experience capability shortages. As the Marine Corps continues to upgrade their arsenal in this time of economic strife, it is imperative that they purchase the right gear, at the right time, for the right purpose. As the Marine Corps continues the process of designing and building the new CH-53K, it is imperative that they look at other relative programs to make sure they get the best product that the government money can buy.

With the current MV-22's price tag skyrocketing and the future budgetary environment changing, the Marine Corps needs to reevaluate whether they are purchasing the right mix of assault support aircraft to accomplish all future missions. Where the MV-22 does have its advantages with speed and range, the CH-53K proves to be a more capable aircraft due to the size and lift capability. In addition, the individual cost of the more capable CH-53K will be

roughly half that of the MV-22. This is critical as the new presidential administration takes over and will make cuts to the DOD budget over the next few years.

As the Marine Corps continues to purchase aircrafts such as the CH-53K and MV-22, it is more important that we focus on mission success. The Marine Corps should invest more time and energy in refining the operational concepts to be more reflective of the threat and operational environments it will deal with in the coming years. Currently, with 2015 being right around the corner, and the question of what the MV-22's external lift capability will be, requires the Marine Corps to take a critical look at the aircrafts ability and assess whether or not a MEU or MEB can accomplish OMFTS, STOM, and FE. The Marine Corps must ensure the acquisition corps and Marine Corps Combat Development Command work together to acquire the right mix of assets to allow for future success. In addition, if we continue getting heavier, the CH-53K's inability to external lift two vehicles simultaneously will also seriously affect STOM. Ultimately, the Marine Corps will need to put all ground and aviation programs on the same page or we will again make compromises on the backs of the Marines.

Consequently, the Marine Corps needs to attempt to bring its equipment and conceptual efforts into better alignment. If not done, they will run the risk of equipping Marines in ways that may cost money and life, yet still not accomplish the intended mission. The focus of the Marine Corps should be the accomplishment of the mission and objectives in this complex and dangerous world, not the acquisition of equipment due to the amount of money previously invested. Over the years the Marine Corps has become wedded to the MV-22 plan. It is now time for the Marine Corps to look at the CH-53K and MV-22 to determine which aircraft has more capabilities for the cost when fighting in future operations, only then will they come up with the right answer.

Appendix A

History of the CH-53

In 1960, the USMC began looking for a replacement to their old S-56 piston-powered helicopters. By 1962, the US Navy Bureau of Weapons issued a request for a Heavy Helicopter Experimental (HH(X)). The specifications dictated a load capability of 8,000 pounds with an operational radius of 100 nautical miles at a speed of 150 knots. The mission of the HH(X) would be assault transport, aircraft recovery, personnel transport, and medical evacuation roles. Although the HH(X) can conduct all the standard assault-support missions, Sikorsky designed it to carry heavy equipment rather than troops.³⁷

The new requirement created an intense competition between Boeing and Sikorsky, with the Boeing design having a slight advantage. The advantage was two-fold, since the United States Army was already in development of their heavy lift helicopter, the Chinook, and the U.S. Defense Secretary Robert S. McNamara wanted "commonality" between the armed services. Considering the pressure, the Marines managed to convince McNamara's staff that the changes required to make the Chinook shipboard capable would be too expensive. Sikorsky pressed with their new design and ultimately received the contract award in July 1962.³⁸

On 14 October 1964, the first YCH-53A performed its initial flight at the Sikorsky plant. The Marines subsequently placed an order for sixteen aircraft in September 1964 and by September 1965; they already received their first CH-53A Sea Stallion. The fast acquisition of these helicopters was due to the Marine Corps being in such dire need of lift pushing them to acquire the helicopter prior to their test and evaluation trials were complete. In the end, the Marine Corps would purchase one hundred forty one CH-53A helicopters.³⁹

The CH-53A's primary mission is the movement of cargo and equipment. It has a secondary role of transferring troops ashore when conducting amphibious assaults. The CH-53A is also equipped with a six-bladed main rotor and four-bladed tail rotor system. To conserve space on naval shipping, the main rotors and the tail boom could fold. The CH-53A has a crew of four, consisting of the pilot, copilot, crew chief, and aerial observer. It was designed to carry either thirty-eight troops, twenty four litters with medical attendants, an internal cargo load of 8,000 pounds, or an external load of 13,000 pounds on the single-point hook.⁴⁰

The CH-53A arrived in Vietnam in January 1967, just over two years after the introduction to the fleet. It quickly proved its usefulness by recovering a number of downed aircraft. Nevertheless, the tropical climate of Vietnam regularly pushed the CH-53A beyond its power margin, requiring the Marines to search for a replacement with more power. First introduced in 1966, the CH-53D is a more capable version of the CH-53A, consisting of improved engines, an up-rated transmission to take advantage of the more powerful engines, and a revised interior to permit 55 troops. The initial flight of the CH-53D was on 27 January 1969, with initial service deliveries later that year. Sikorsky built and delivered 126 CH-53D's to the Marines by 1974. Both the CH-53A and the CH-53D served side by side during the remainder of the Vietnam War. Both acquired a superb reputation when conducting troop inserts, heavy lift missions, resupply and tactical recovery of aircraft and personnel. Eventually, by the early 1990s, the older CH-53A's were all retired, but the CH-53D's remain in service today. The plan is for the Marines to replace their CH-53D's with the MV-22 Osprey tilt rotor.⁴¹

Although the CH-53D proved to be a much better heavy lift aircraft than the CH-53A, the CH-53D still lacked the lifting power that the Marine Corps required since they still could not pick up the preponderance of the fleets heavy gear. Subsequently, in October 1967, the Marines

issued a Specific Operational Requirement for a heavy lift helicopter that would have 1.8 times that of the CH-53D and still fit on amphibious shipping. At the same time, the Army and Navy were also searching for a heavy lift helicopters for its service related missions.⁴²

The Army began to design a replacement focusing on the Boeing version, which was to be similar to an up-scaled Chinook. Furthermore, Defense Secretary Melvin Laird put pressure on the three services to obtain a common solution, but received little cooperation from the services since each would have there own requirements. In 1970, Laird finally ordered the three services to acquire the Army heavy lift version. Lairds' order created internal protests by the Marines and Navy, since the Army version would be too cumbersome to operate from naval shipping. In September 1971, after much debate, Congress gave the Marines and the Navy permission to continue with the Sikorsky design. Shortly after, the Marine signed the contract for the first two prototypes of the YCH-53E.⁴³

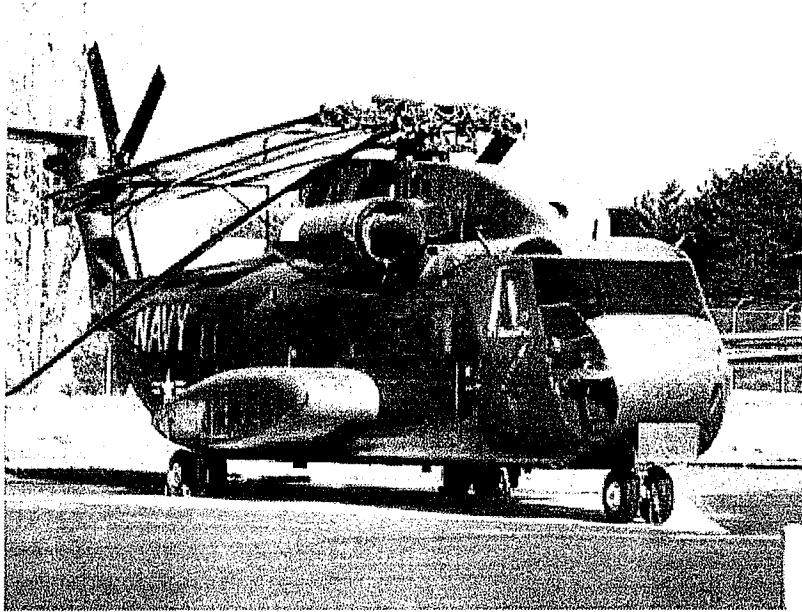
On 1 March 1974, Sikorsky conducted the first flight of the YCH-53Es at its Stratford, Connecticut plant. The airframe was similar to that of the CH-53D, but with three turbo shaft engines, seven main rotor blades, and a 20 degree canted tail section. The CH-53E Super Stallion could carry up to 55 troops, had an internal cargo capacity of 30,000 pounds, and an external load capability of 36,000 pounds. The Marine Corps awarded the initial production contract in 1978, allowing the first aircraft to enter the fleet in February 1981. The Marine Corps quickly built up their inventory of the CH-53E and found it had great capabilities with personnel transport, aircraft recovery, transport of artillery and light armored vehicles.⁴⁴

Despite the size of the helicopter, many consider its speed and agility to be exceptional. The CH-53E designed new safety features into the airframe including the flight control system, which kept the pilot from overstressing the airframe. The US Navy would also find uses for the

CH-53E and acquired them in small numbers for shipboard resupply and minesweeping missions. Over the nineteen-year production run, the Marines and Navy would acquire 177 H-53E helicopters.⁴⁵

Appendix B

Figure 1: CH-53A



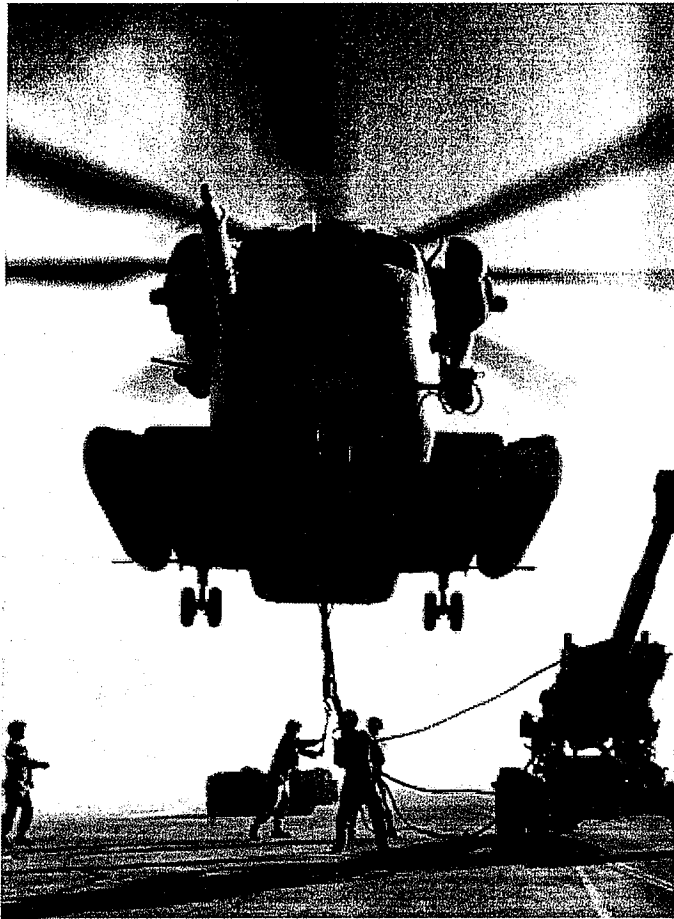
Source: <http://www.paxmuseum.com/ch53/ch53.htm>

Figure 2: CH-53D



Source: http://en.wikipedia.org/wiki/CH-53_Sea_Stallion

Figure 3: CH-53E



Source: <http://cache.daylife.com/imageserve/08Of5L15zNcgR/340x.jpg>

Figure 4: Joint Heavy Lift Replacement



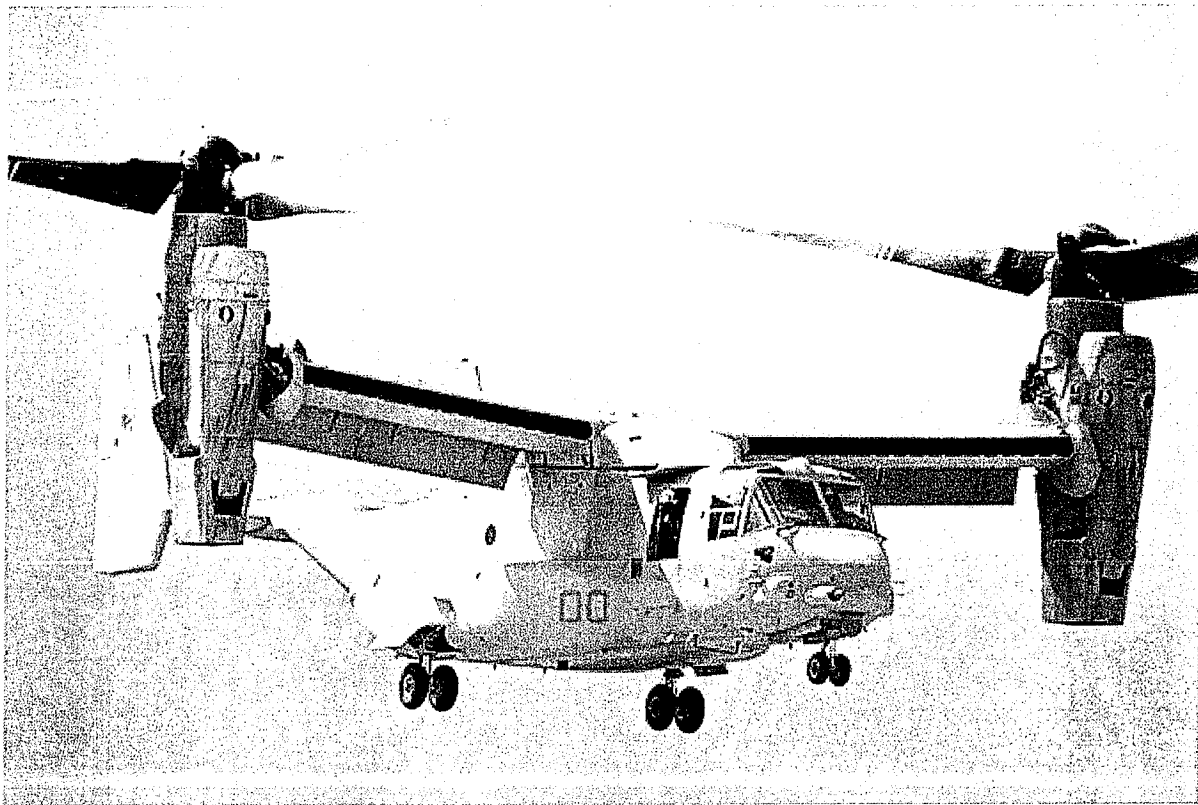
Source: http://www.defenseindustrydaily.com/images/AIR_Bell-Boeing_QTR_Concept_lg.jpg

Figure 5: CH-53K



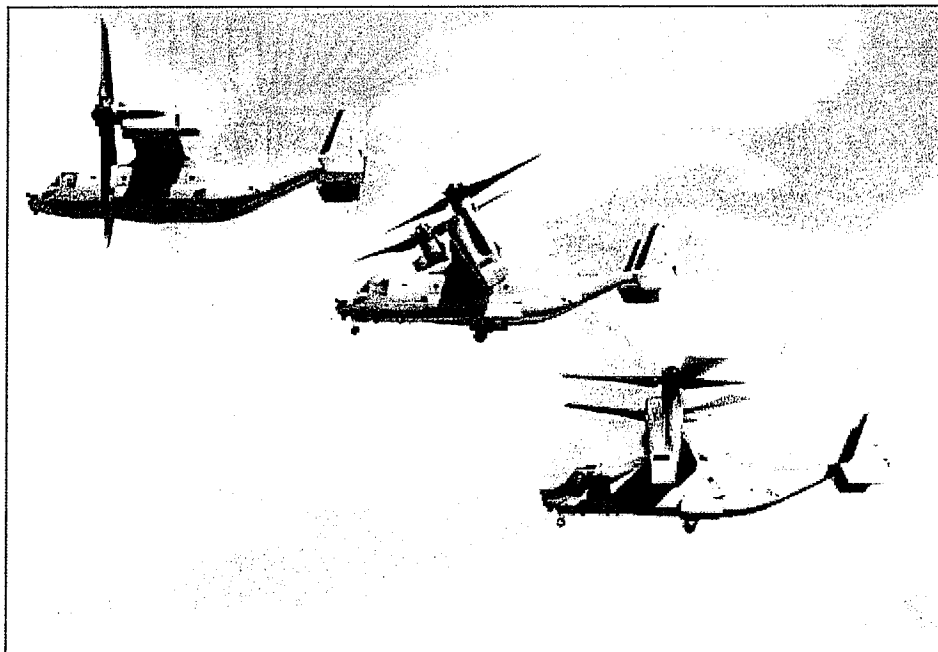
Source: http://www.defenseindustrydaily.com/images/PUB_CH-53K_Notional_Mission_Profile_lg.gif

Figure 6: Marine Corps MV-22



Source: http://www.enemyforces.net/helicopters/v22_osprey.htm

Figure 7: V-22 Transition

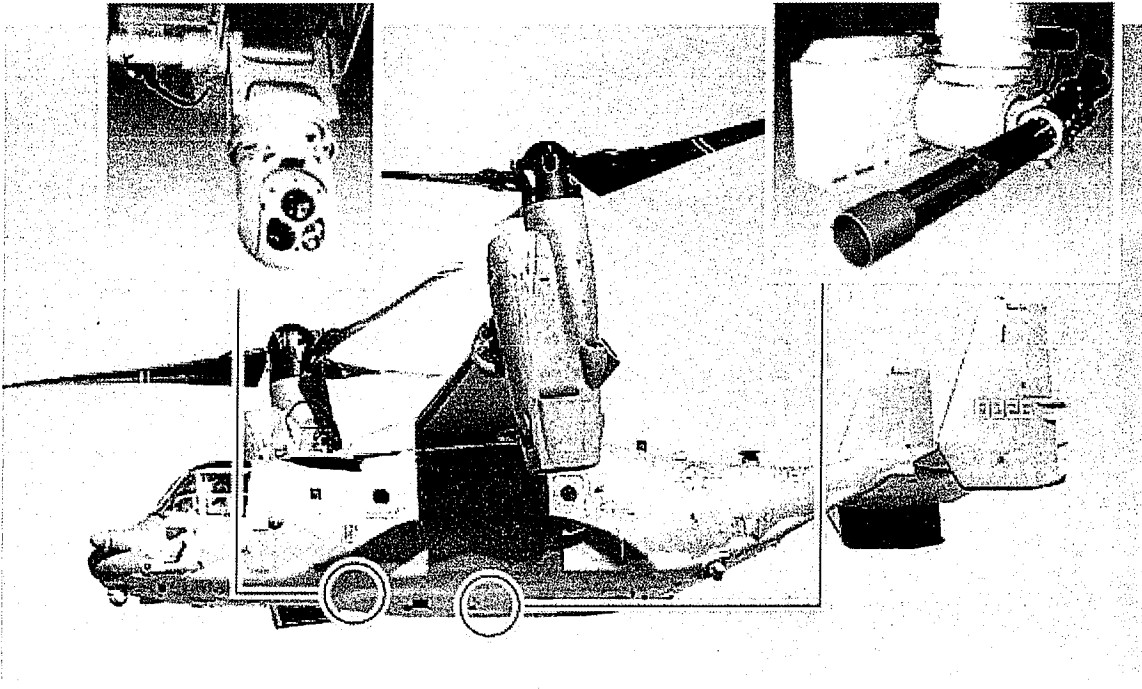


Source: <http://www.helicopterpage.com/tiltroto/transition.gif>

Figure 8: BAE V-22 weapon System

TILT-ROTOR TURRETS

Air Force Special Operations Command plans to install turret-mounted guns on seven CV-22 Ospreys next year and is testing an interim version now.



Source: BAE Systems, Air Force

STAFF

Source: http://www.airforcetimes.com/news/2009/01/airforce_osprey_gun_010409/

Bibliography

- Button, Robert W., et al. Warfighting and Logistic Support of Joint Forces from the Joint Sea Base. Santa Monica, CA: Rand Corporation, 2007.
- Congressional Research Reports for the People. V-22 Osprey Tilt-Rotor Aircraft. 02 January 2009. <<http://openocrs.com/document/RL31384>> (12 February 2009).
- Defense Industry Daily. CH-53K: The U.S. Marines' HLR Helicopter Program (updated). 02 June 2008. <<http://www.defenseindustrydaily.com/ch53k-the-us-marines-hlr-helicopter-program-updated-01724/>> (23 January 2009).
- Defense Industry Daily. V-22 Osprey: A Flying Shame. 31 March 2008. <<http://www.defenseindustrydaily.com/V-22-Osprey-A-Flying-Shame-04822/>> (03 February 2009)
- Department of Defense. Seabasing Joint Integrating Concept. 01 August 2005. <http://www.dtic.mil/futurejointwarfare/concepts/jic_seabasing.doc> (20 January 2009).
- Global Security. F-84 F "Thunderstreak". <<http://www.globalsecurity.org/military/systems/aircraft/f-84f.htm>> (05 February 2009).
- Goebel, Greg. Sikorsky Giant Helicopters: S-64, S-65, & S-80. March 1, 2008. <<http://www.vectorsite.net/avskbig.html#m2>> (21 January 2009).
- Gordon IV, John., et al. Assessment of Navy Heavy Lift Options. Santa Monica, CA: Rand Corporation, 2005.
- Headquarters U.S. Marine Corps. The Long War – Send in the Marines: A Marine Corps Operational Employment Concept to Meet an Uncertain Security Environment. Quantico MCB, VA: Headquarters U.S. Marine Corps, 2008.
- Headquarters U.S. Marine Corps. Expeditionary Maneuver Warfare: Marine Corps Capstone Concept. Quantico MCB, VA: Headquarters U.S. Marine Corps, 2001.
- Headquarters U.S. Marine Corps. Operational Maneuver from the Sea: A Concept for the Projection of Naval Power Ashore. Washington D.C.: Headquarters U.S. Marine Corps, 1999.
- Hoffman, Michael. Air Force Times: All quadrant gun set for Osprey installation. 07 January 2009. <http://www.airforcetimes.com/news/2009/01/airforce_osprey_gun_010409/> (17 February 2009).
- Military.com. Armored Vehicle Cut Threatens Industry. 5 December 2007 <<http://www.military.com/NewsContent/0,13319,157595,00.html>> (01 February 2009).

- Milliman, John. UH-1Ys to be built new starting in 06. 22 April 2005.
<http://www.news.navy.mil/search/displaybbs.asp?bbs_id=1332&cat=5> (17 February 2009).
- Naval Aviation History Office, CH-53A/D/E Sea Stallion and MH-53E Sea Dragon, 15 November 2000, <<http://www.history.navy.mil/planes/ch53.htm>> (22 April 2009).
- Robbins, Darron L. and Smith, Michael W. Re-Supplying Forces Ashore Using Sea-Based Aircraft. Alexandria, VA: Center for Naval Analyses, 2006.
- The Free Library. U.S. Marine Corps press release (09 January 2006): new heavy lift helicopter starts development. 01 May 2006. <[http://www.thefreelibrary.com/U.S. Marine Corps press release \(Jan. 9, 2006\): new heavy lift...-a0146264826](http://www.thefreelibrary.com/U.S.+Marine+Corps+press+release+(Jan.+9,+2006):+new+heavy+lift...-a0146264826)> (19 January 2009).
- Thompson, Mark. Time Magazine. V-22 Osprey: A Flying Shame. 26 September 2007.
<<http://www.time.com/time/politics/article/0,8599,1665835,00.html>> (02 February 2009).
- U.S. Marine Corps Combat Development Command. Ship-To-Objective Maneuver. Quantico MCB, VA: U.S. Marine Corps Combat Development Command, 1997.
- U.S. Marine Corps Combat Development Command. Marine Corps Operating Concepts for a Changing Security Environment. Quantico MCB, VA: U.S. Marine Corps Combat Development Command, 2006.
- Wood, Dakota L. U.S. Marine Corps: Fleet Marine Forces for the 21st Century. Strategy for the Long Hall. The Center for Strategic and Budgetary Assessments, 2008.

Notes

¹ The Free Library, U.S. Marine Corps press release (9 January 2006): new heavy lift helicopter starts development, 01 May 2006, <[http://www.thefreelibrary.com/U.S. Marine Corps press release \(Jan. 9, 2006\): new heavy lift...-a0146264826](http://www.thefreelibrary.com/U.S.+Marine+Corps+press+release+(Jan.+9,+2006):+new+heavy+lift...-a0146264826)> (19 January 2009).

² Defense Industry Daily, CH-53K: The U.S. Marines' HLR Helicopter Program (updated), 02 June 2008, <<http://www.defenseindustrydaily.com/ch53k-the-us-marines-hlr-helicopter-program-updated-01724/>> (23 January 2009).

³ Headquarters U.S. Marine Corps, Expeditionary Maneuver Warfare: Marine Corps Capstone Concept (Quantico MCB, VA: Headquarters U.S. Marine Corps, 2001), 6.

⁴ Naval Aviation History Office, CH-53A/D/E Sea Stallion and MH-53E Sea Dragon, 15 November 2000, <<http://www.history.navy.mil/planes/ch53.htm>> (22 April 2009).

⁵ Defense Industry Daily, CH-53K: The U.S. Marines' HLR Helicopter Program (updated), 02 June 2008, <<http://www.defenseindustrydaily.com/ch53k-the-us-marines-hlr-helicopter-program-updated-01724/>> (23 January 2009).

⁶ Defense Industry Daily: CH-53K.

⁷ Defense Industry Daily: CH-53K.

⁸ The Free Library.

⁹ Global Security, F-84 F "Thunderstreak", <<http://www.globalsecurity.org/military/systems/aircraft/f-84f.htm>> (05 February 2009).

¹⁰ John Milliman, UH-1Ys to be built new starting in 06, 22 April 2005, <http://www.news.navy.mil/search/displaybbs.asp?bbs_id=1332&cat=5> (17 February 2009).

¹¹ John Gordon IV et al., Assessment of Navy Heavy Lift Options (Santa Monica, CA: Rand Corporation, 2005), 2.

¹² Gordon, 42.

¹³ Mark Thompson, Time Magazine: V-22 Osprey: A Flying Shame, 26 September 2007, <<http://www.time.com/time/politics/article/0,8599,1665835,00.html>> (02 February 2009).

¹⁴ Congressional Research Reports for the People, V-22 Osprey Tilt-Rotor Aircraft, 02 January 2009, <<http://opencrs.com/document/RL31384>> (12 February 2009).

¹⁵ Congressional Research Reports for the People.

¹⁶ Thompson.

¹⁷ Dakota L. Wood, U.S. Marine Corps: Fleet Marine Forces for the 21st Century. Strategy for the Long Hall. (Washington D.C.: The Center for Strategic and Budgetary Assessments, 2008), 20.

¹⁸ Defense Industry Daily, V-22 Osprey: A Flying Shame, 31 March 2008, <<http://www.defenseindustrydaily.com/V-22-Osprey-A-Flying-Shame-04822/>> (3 February 2009)

¹⁹ Michael Hoffman, Air Force Times: All quadrant gun set for Osprey installation, 07 January 2009, <http://www.airforcetimes.com/news/2009/01/airforce_osprey_gun_010409/> (17 February 2009).

²⁰ Wood, 19.

²¹ Military.com, Armored Vehicle Cut Threatens Industry, 5 December 2007, <<http://www.military.com/NewsContent/0,13319,157595,00.html>> (1 February 2009).

²² Wood, 19.

²³ Headquarters U.S. Marine Corps, Operational Maneuver from the Sea: A Concept for the Projection of Naval Power Ashore, (Washington D.C.: Headquarters U.S. Marine Corps, 1999), 5.

²⁴ Headquarters U.S. Marine Corps, Operational Maneuver from the Sea: A Concept for the Projection of Naval Power Ashore, 6.

²⁵ Headquarters U.S. Marine Corps, Operational Maneuver from the Sea: A Concept for the Projection of Naval Power Ashore, 2.

²⁶ U.S. Marine Corps Combat Development Command, Ship-To-Objective Maneuver, (Quantico MCB, VA: U.S. Marine Corps Combat Development Command, 1997), II-4.

²⁷ Department of Defense, Seabasing Joint Integrating Concept, 01 August 2005, <http://www.dtic.mil/futurejointwarfare/concepts/jic_seabasing.doc> (20 January 2009), 5

²⁸ Robert W. Button et al., Warfighting and Logistic Support of Joint Forces from the Joint Sea Base (Santa Monica, CA: Rand Corporation, 2007), 1.

²⁹ Department of Defense, Seabasing Joint Integrating Concept, 5

³⁰ Darron L. Robbins and Michael W. Smith, Re-Supplying Forces Ashore Using Sea-Based Aircraft (Alexandria, VA: Center for Naval Analyses, 2006), 2.

³¹ Robbins, 43-46.

³² U.S. Marine Corps Combat Development Command, Marine Corps Operating Concepts for a Changing Security Environment, (Quantico MCB, VA: U.S. Marine Corps Combat Development Command, 2006), 35.

³³ U.S. Marine Corps Combat Development Command, Marine Corps Operating Concepts for a Changing Security Environment, V.

³⁴ U.S. Marine Corps Combat Development Command, Marine Corps Operating Concepts for a Changing Security Environment, 34.

³⁵ U.S. Marine Corps Combat Development Command, Ship-To-Objective Maneuver, II 4-5.

³⁶ Defense Industry Daily, V-22 Osprey: A Flying Shame.

³⁷ Greg Goebel, Sikorsky Giant Helicopters: S-64, S-65, & S-80, March 1, 2008.
<<http://www.vectorsite.net/avskbig.html#m2>> (21 January 2009).

³⁸ Goebel

³⁹ Goebel

⁴⁰ Goebel

⁴¹ Goebel

⁴² Goebel

⁴³ Goebel

⁴⁴ Goebel

⁴⁵ Goebel